Feeder Protection REF615 ANSI

Product Guide

Contents

1. Description

The REF615 is a powerful and simple feeder protection relay designed for the protection, control, measurement and monitoring of utility substations and industrial power systems. Engineered from the ground up, the relay has been guided by the IEC 61850 standard for communication and interoperability of substation automation devices.

The relay provides main protection for overhead lines, cable feeders and busbar systems in distribution substations. The relay is also used as back-up protection in applications, where an independent and redundant protection system is required such as in transformer protection.

Depending on the preconfiguration made, the relay is adapted for the protection of overhead line and cable feeders in grounded and ungrounded distribution systems.. Once the standard configuration relay has been given the application-specific settings, it can directly be put into service.

The 615 series relays support a range of communication protocols including IEC 61850 with GOOSE messaging, DNP3.0 and Modbus®.

2. Standard configurations

The feeder protection relay REF615 is available with three alternative standard configurations. The table below indicates the functions supported by the different relay configurations.

** The DNP3.0 implementation includes some Level 3 functionality.*

Standard Configurations

Functions		Analog Inputs	3 CT	3 CT + Ground CT	3 CT + SEF CT
		Order Code	AA	AB	AC
Protection	**ANSI**				
Phase overcurrent protection, 4 elements	51P, 50P-1, 50P-2, 50P-3		●	●	●
Phase long time overcurrent protection	51LT		●	●	●
Neutral overcurrent protection, 4 elements	51N, 50N-1, 50N-2, 50N-3		●	●	●
Ground overcurrent protection, 4 elements	51G, 50G-1, 50G-2, 50G-3			●	
Sensitive earth fault protection	50SEF				●
Negative sequence overcurrent protection, 2 elements	46-1, 46-2		●	●	●
High impedance fault protection	HIZ				●
Thermal overload protection	49F		●	●	●
Phase discontinuity protection	46PD		●	●	●
Cold load inrush detection, 2 elements	62CLD-1, 62CLD-2		●	●	●
Circuit breaker failure protection	50BF		●	●	●
Electrically latched/self-resetting trip outputs	86/94-1, 86/94-2		●	●	●
Arc flash detection via three lens sensors	AFD-1, AFD-2, AFD-3		○	○	○
Control					
Circuit breaker control	52-1		●	●	●
Autoreclose	79			○	○
Monitoring and Supervision					
Trip circuit monitoring	TCM		●	●	●

● = Included,
○ = Optional

Standard Configurations

Functions		Analog Inputs	3 CT	3 CT + Ground CT	3 CT + SEF CT
		Order Code	AA	AB	AC
Measurement					
Three-phase currents	IA, IB, IC		•	•	•
Sequence currents	I1, I2, I0		•	•	•
Ground current	IG			•	
Demand phase currents			•	•	•
Maximum demand phase currents			•	•	•
Automation & Communications					
10/100BaseT Ethernet (RJ45): Supports DNP3.0 Level 2+, Modbus and IEC61850			o	o	o
100BaseFL Ethernet (LC): Supports DNP3.0 Level 2+, Modbus and IEC61850			o	o	o
Records					
Sequence of events (SOE) recorder	SER		•	•	•
Fault recorder	FLR		•	•	•
Digital fault (waveform) recorder	DFR		•	•	•

• = Included,
o = Optional

3. Protection functions

The REF615 offers time and instantaneous overcurrent, negative sequence overcurrent, phase discontinuity, breaker failure and thermal overload protection. Optional features include high impedance fault (HIZ) detection and sensitive earth fault (SEF) protection. The relay also offers an optional three-phase multi-reclose function for automatic feeder restoration with temporary faults on overhead lines.

Enhanced with an arc-flash safety option,, the relay also features three light detection channels for arc fault detection of the circuit breaker, busbar and cable compartment of metal-enclosed switchgear.

The arc-fault detection sensor interface is available on the optional communication module. Fast tripping increases personal safety and limits material damage within the switchgear in an arc fault situation.

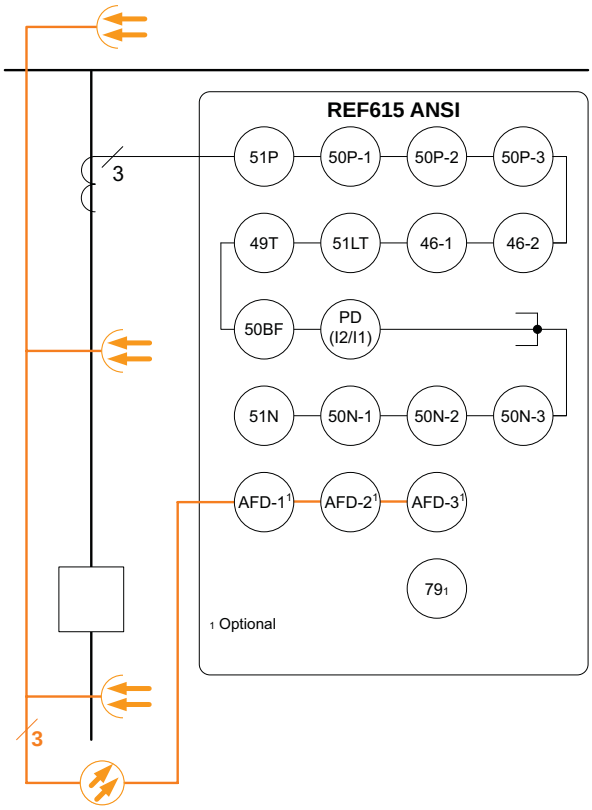

Fig. 1 Protection function overview of the “3 CT” configuration

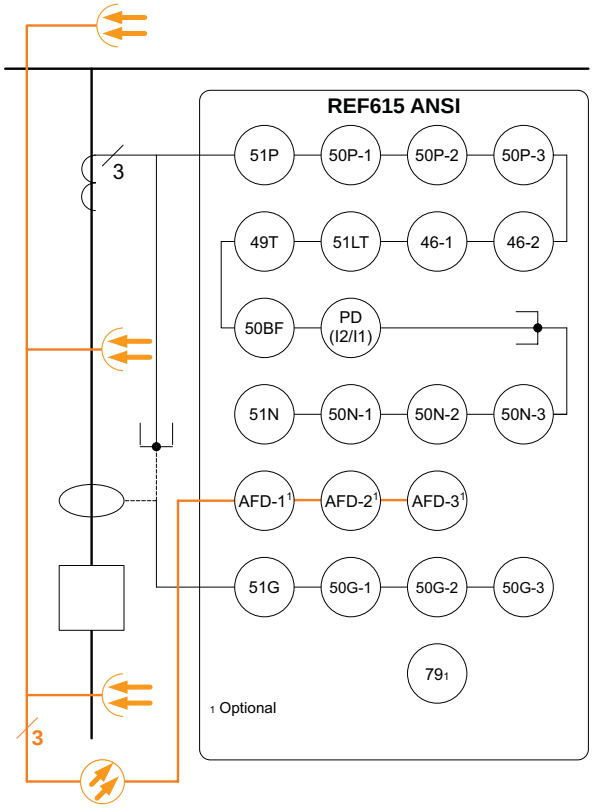

Fig. 2: Protection function overview of “3CT + Ground CT” configuration

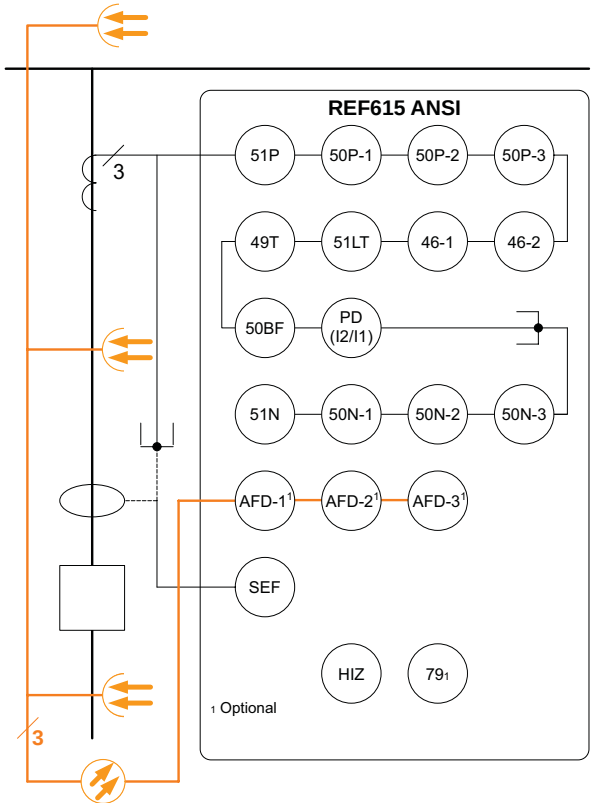

Fig 3: Protection overview of 3CT + SEF CT configuration” Visio one-line diagram.

4. Application

The feeder protection relay REF615 ANSI model can be supplied with or without a dedicated ground or sensitive earth ct input. For those protection schemes where a ground ct is unavailable or undesirable, the three-phase ct inputs-only model eliminates additional wiring associated with an external residual connection. This model performs an internal neutral (IN) calculation using the three phase ct inputs and provides numerous neutral overcurrent protection elements for ground fault protection.

Where a dedicated ground ct, sensitive earth protection and high impedance fault (HIZ) detection is required, additional models can be ordered that include a fourth ct input. The dedicated ground ct affords ground overcurrent protection via an external residual connection or window ct while the SEF ct option provides both SEF and HIZ protection.

Including a HIZ protective function incorporating ABB's patented high impedance fault detection alogorithms in the SEF option enables the REF615 to be applied as a stand-alone HIZ detector wired with any existing feeder protection relay from any vendor.

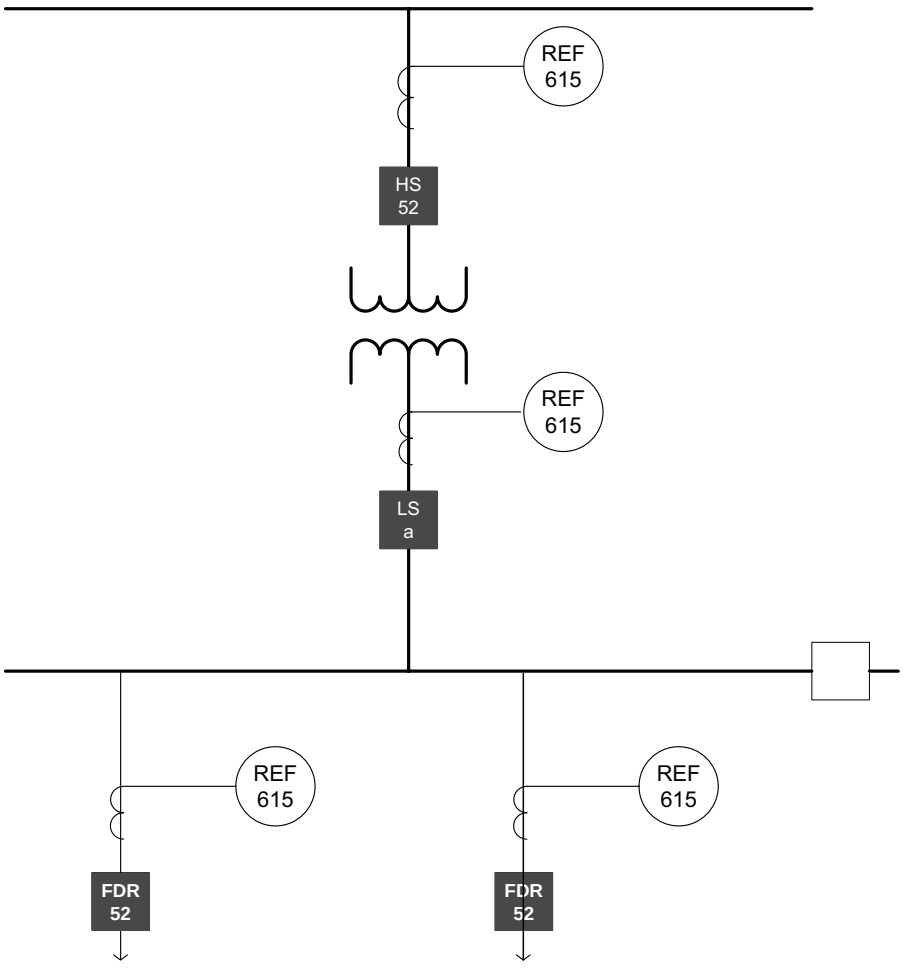

Fig. 4 Substation feeder, bus and backup overcurrent protection with the REF615 ANSI configurations with optional reclosing, SEF, HIZ and arc protection.

Figures 4-6 show protection application examples possible with the various REF615 ANSI model options. Its simple design and small size makes for a convenient solution for primary feeder and backup overcurrent protection schemes.

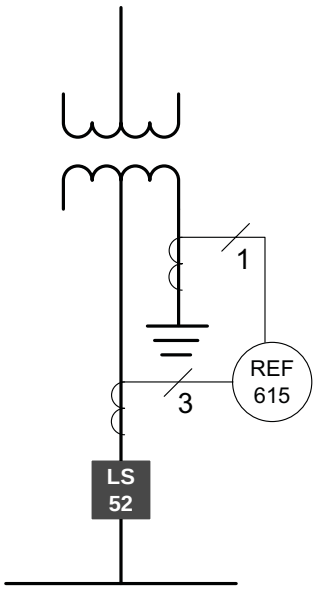

Fig. 5a

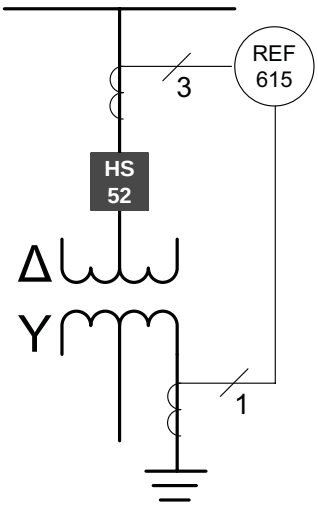

Fig. 5b

Fig. 5 Backup protection a) bus and transformer and b) transformer.

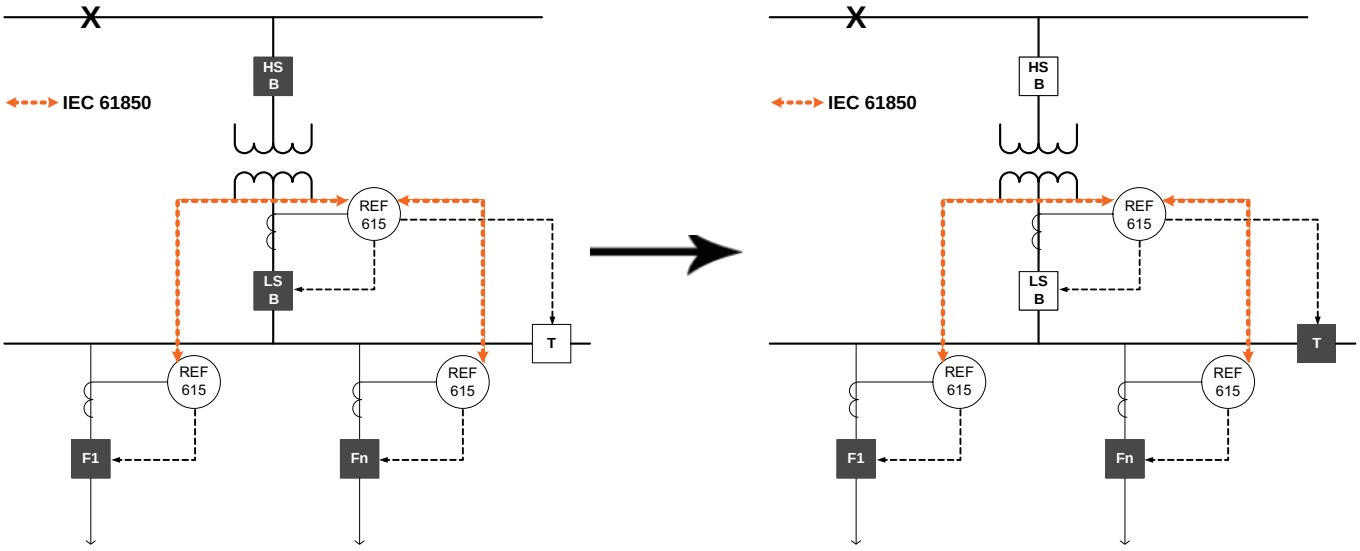

Fig. 6 Peer-to-peer relay control via IEC 61850 GOOSE messaging and Cat 5 or fiber optic communications.

5. Control

The relay offers status and control of one circuit breaker with dedicated push-buttons on the front panel local human machine interface (LHMI) for opening and closing. Flexible remote breaker control a select-before-operate (SBO) or direct operate is also available with each of the supported DNP3.0, Modbus and IEC 61850 communication protocols. Interlocking schemes required by the application are configured with the signal matrix tool in PCM600.

6. Measurement

The relay continuously measures the phase currents, the sequence components of the currents and the residual current. If the relay includes the ground ct option, it also measures the ground current, IG. In addition, the relay calculates the demand phase currents over a user-selectable pre-set time frame, the thermal overload of the protected object, and the phase unbalance value as a ratio between the negative sequence and positive sequence currents.

The values measured can be accessed locally via the user interface on the relay front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the web-browser based user interface.

7. Digital fault recorder

The relay is provided with a digital fault recorder (DFR) featuring up to eight analog and 32 binary signal channels. The analog channels record either the waveform or the trend of the currents measured.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording on the rising or the falling edge of the binary signal or both.

By default, the binary channels are set to record external or internal relay signals, e.g. the pickup or trip signals of the relay stages, or external blocking or control signals. Binary relay signals such as a protection pickup or trip signal, or an external relay control signal over a binary input can be set to trigger the recording.

8. Events recorder

The IED includes a sequence of events recorder (SER) that logs important event activity. To collect sequence-of-events (SER) information, the relay incorporates a memory with a capacity of storing 50 event codes with associated time stamps. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances.

The SoE information can be accessed locally via the user interface on the relay front panel or remotely via the communication interface of the relay. The information can further be accessed, either locally or remotely, using the web-browser based user interface.

9. Fault recorder

The relay has the capacity to store the records of 100 fault events. The records enable the user to analyze the four most recent power system events. Each record includes the current values, the start times of the protection blocks, time stamp, etc. The fault recording can be triggered by the pickup signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. In addition, the maximum demand phase currents with date and time stamp are separately stored as recorded data. All 100 records are remotely retrievable via DNP3.0 and Modbus protocols and the four most recent fault records are retrievable and viewable using the front panel HMI, WMHI and PCM600 interfaces.

10. Circuit-breaker monitoring

The REF615 includes a circuit breaker failure protection feature that can monitor correct breaker operation when controlled. With the standard compliment of available outputs, a breaker failure condition can be mapped to a power output to drive a backup breaker and a signal output to alarm on breaker failure. Additional breaker monitoring features will be available in a future release.

11. Trip-circuit monitoring

The trip-circuit monitoring continuously supervises the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in its closed and in its open position. It also detects loss of circuit-breaker control voltage.

Local and remote indication are programmable to ensure immediate notification so the necessary steps can be established to correct before the next fault event occurs.

12. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected will be used for alerting the operator. A permanent relay fault will block the protection functions of the relay to prevent incorrect relay operation.

13. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the viewer, operator, engineer and administrator levels. The access control applies to the front-panel user interface, the web-browser based user interface and the PCM600 user interface tool.

14. Inputs and outputs

Depending on the standard configuration selected, the relay is equipped with three-phase ct inputs for basic phase and neutral overcurrent backup protection, three-phase and ground ct inputs for phase and ground overcurrent protection or three-phase and sensitive earth ct inputs for phase, neutral, SEF and HIZ protection.

The phase-current inputs are programmable for 5 A or 1 A ct secondary nominal rating. The ground ct option is programmable for 5/1 A nominal rating, the SEF ct option has a 0.2 A nominal rating. The sensitive earth ct option provides SEF protection and includes a separate, independent HIZ protective function for detecting downed conductors..

The phase-current input 5 A or 1 A, the ground input 5 A or 1 A, or alternatively, the sensitive earth input 0.2 A nominal ratings, are selected in the relay software.

The binary input turn-on thresholds are programmable from 18…176 V DC by adjusting the relay's parameter settings.

All binary input and output contacts are freely programmable with the signal matrix tool in PCM600 software user tool.

Relay analog input and binary input/output overview:

- Three or four current inputs
- Optional ground or sensitive earth ct current input.
- Programmable four physical inputs and six physical outputs standard.
- Two normally-open power output contacts
- Two changeover signal-output contacts
- Two double-pole power-output contacts with trip-circuit supervision
- One dedicated self-check alarm output contact

I/O extension module:

- Seven programmable physical inputs
- Three programmable signal-output contacts

15. Communication

The relay supports three different communication protocols: IEC 61850 , DNP3.0 Level 2+ and Modbus®. Operational information and controls are available through these protocols. Unique communication functionality, for example, peer-to-peer communication between relays is available via the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter setting and disturbance file records can be accessed using the IEC 61850-8-1 protocol. Further, the relay can send and receive binary signals from other relays (peer-to-peer communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. The relay can simultaneously report to five different clients - maximum five IEC 61850-8-1 clients, maximum five Modbus clients and maximum one DNP3.0 client with total number not exceeding five.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The relay can be connected to Ethernetbased communication systems via the RJ-45 connector (100BASE-TX) or the fibreoptic LC connector (100BASE-FX).

Modbus over TCP/IP is supported with the Ethernet communications option selected. Besides standard Modbus functionality such as status and control operations, the relay supports retrieval of time-stamped events, uploading of disturbance files and storing of the latest fault records. For the Modbus TCP connection, a maximum of , five clients can be connected to the relay simultaneously.

DNP3.0 over TCP/IP is also supported with the Ethernet communications card option. Status and control, including breaker trip/close control, operations are supported in the Level 2+ implementation.

The relay supports the time synchronization with a time-stamping resolution of +/-1 ms:

Ethernet based:

- SNTP (primary and secondary server support)

		Communications Interface	
		100BASE-TX (RJ45)	100BASE-FX (LC)
Protocol	DNP3.0 over TCP/IP	•	•
	Modbus over TCP/IP	•	•
	IEC 61850-8-1	•	•

• = Supported

16. Technical data

Dimensions

Width	frame case	6.97” (177 mm) 6.57” (165 mm)
Height	frame case	6.97 (177 mm), 4U 6.30” (160 mm)
Depth	case	6.10” (155 mm)
Weight	relay draw-out unit	7.72 lbs. (3.5 kg) 3.97 lbs. (1.8 kg)

Power Supply

Type:	**Type 1**	**Type 2**
V nominal (V_n)	100, 110, 120, 220, 240 V AC, 60 and 50 Hz 48, 60, 110, 125, 220, 250 V DC	24, 30, 48, 60 V DC
V_n variation	85...110% of V_n (85...264 V AC) 80...120% of V_n (38.4...300 V DC)	50...120% of V_n (12...72 V DC)
Start-up threshold		19.2 V DC (24 V DC * 80%)
Burden of auxiliary voltage supply under quiescent (Pq)/operating condition	<8.4 W/13 W	
Ripple in the DC auxiliary voltage	Max 12% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at V_n rated	
Fuse type	T2.5A/250 V	

Energizing inputs

Rated frequency		60/50 Hz ± 5 Hz	
Current inputs	Rated current, I_n	5/1 A [1]	1/0.2 A [2]
	Thermal withstand capability: • Continuously • For 1 s • For 10 s	 20 A 500 A 100 A	 4 A 100 A 25 A
	Dynamic current withstand: • Half-wave value	 1250 A	 250 A
	Input impedance	<20 mΩ	<100 mΩ

[1] Phase and ground current inputs
[2] Sensitive earth fault (SEF) current input

Measuring range

Measured currents on phases IA, IB and IC as multiples of the rated currents of the energizing inputs	0... 50 x I_n
Ground current as a multiple of the rated current of the energizing input	0... 50 x I_n

Binary inputs

Operating range	±20 % of the rated voltage
Rated voltage	24...250 V DC
Current drain	2...18 mA
Power consumption/input	<0.9 W
Threshold voltage	18...176 V DC

Signal outputs (SO) [Typical operation time is 5-8 ms.]

Rated voltage	250 V AC/DC
Continuous carry	5 A
Make and carry for 3.0 s	15 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Self-check alarm relay change over - type signal output relay [Typical operation time is 5-8 ms.]	
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	15 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Power outputs (PO) [Typical operation time is 8-11 ms.]

Double-pole power output with trip-circuit supervision function	
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit monitoring (TCM): • Control voltage range • Current drain through the monitoring circuit • Minimum voltage over the TCM contact	 20...250 V AC/DC ~1.5 mA 20 V AC/DC (15...20 V)

One-pole power output	
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

Lens sensor and optic fiber for arc flash detection (AFD)

Fibre-optic cable including lens	1.5 m, 3.0 m or 5.0 m
Normal service temperature range of the lens	-40° to +212° F (-40° to 100° C)
Maximum service temperature range of the lens, max 1 h	+284° F (+140° C)
Minimum permissible bending radius of the connection fibre	3.94" (100 mm)

Degree of protection of flush-mounted relay

Front side	IP 54
Rear side, top of the relay	IP 40

Environmental conditions and tests

Environmental conditions	
Operating temperature range	-40° to +85° C (-20 C to +55° C continuous)
HMI LCD temperature range	Some degradation in LCD performance outside the temperature range of -25...+55ºC
Relative humidity	<93%, non-condensing
Atmospheric pressure	12.47 - 15.37 psi (86 - 106 kPa)
Altitude	up to 6561 ft. (2000 m)
Transport and storage temperature range	-40...+85ºC

Environmental tests	
Dry heat test (humidity <50%)	According to IEC 60068-2-2 Test values: • 96 h at +55ºC • 16 h at +85ºC
Cold test	According to IEC 60068-2-1 Test values: • 96 h at -25ºC • 16 h at -40ºC
Damp heat test, cyclic	According to IEC 60068-2-30 Test values: • 6 cycles at +25…55°C, humidity 93…95%
Storage test	According to IEC 60068-2-48 Test values: • 96 h at -40ºC • 16 h at +85ºC

Electromagnetic compatibility tests

The EMC immunity test level meets the requirements listed below:	
100 kHz and 1 MHz burst disturbance test: • Common mode • Differential mode	According to IEC 61000-4-18 and IEC 60255-22-1, level 3 2.5 kV 1.0 kV
Electrostatic discharge test • Contact discharge • Air discharge	According to IEC 61000-4-2, IEC 60255-22-2, level 4, and IEEE 37.90.3-2001 6 kV 8 kV

(continued)

Radio frequency interference tests:	
• Conducted, common mode	According to IEC 61000-4-6 and IEC 60255-22-6, level 3 10 V (emf), f = 150 kHz...80 MHz
• Radiated, amplitude-modulated	According to IEC 61000-4-3 and IEC 60255-22-3, level 3 10 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz
• Radiated, pulse-modulated	According to the ENV 50204 and IEC 60255-22-3,level 3 10 V/m, f=900 MHz
Fast transient disturbance tests:	According to IEC 61000-4-4 and IEC 60255-22-4, class B
• All ports	2 kV
• Communication	2 kV
Surge immunity test:	According to IEC 61000-4-5 and IEC 60255-22-5, level 4/3
• All ports	2 kV, line-to-ground, 1kV, line-to-line
• Communication	1 kV, line-to-ground
Power frequency (50 Hz) magnetic field:	According to IEC 61000-4-8, level 5
• Continuous	300 A/m
• 1...3 s	1000 A/m
Power frequency immunity test:	According to IEC 60255-22-7, class A
	300 V rms
• Common mode	150 V rms
• Differential mode	
Voltage dips and short interruptions	According to IEC 61000-4-11
	30%/10 ms
	60%/100 ms
	60%/1000 ms
	>95%/5000 ms
Electromagnetic emission tests:	According to the EN 55011, class A and IEC60255-25
• Conducted, RF emission (mains terminal)	
0.15...0.50 MHz	< 79 dB(µV) quasi peak
	< 66 dB(µV) average
0.5...30 MHz	< 73 dB(µV) quasi peak
	< 60 dB(µV) average
• Radiated RF emission	
0...230 MHz	< 40 dB(µV/m) quasi peak, measured at 32.81 ft (10 m) distance
230...1000 MHz	< 47 dB(µV/m) quasi peak, measured at 32.81 ft (10 m) distance

Insulation and mechanical tests

Insulation tests	
Dielectric tests:	According to IEC 60255-5
• Test voltage	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1min, communication
Impulse voltage test:	According to IEC 60255-5
• Test voltage	5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication
Insulation resistance measurements	According to IEC 60255-5
• Isolation resistance	>100 MΩ, 500 V DC
Protective bonding resistance • Resistance	According to IEC 60255-27 <0.1 Ω (60 s)

Mechanical tests	
Vibration tests (sinusoidal)	According to IEC 60255-21-1, class 2
Shock and bump test	According to IEC 60255-21-2, class 2

Product safety

Complies with the LV directive 2006/95/EC	
Standards	EN 60255-27 (2005), EN 60255-6 (1994)

Data communication for front interface

Front interface: • TCP/IP protocol • Standard CAT 5 Ethernet cable • 10 MBits/s

Protection functions

Three-phase non-directional overcurrent protection (50/51)

Basic settings	51P Pickup	0.05 - 5.00 x In, step 0.01 x In		
	50P-1, 50P-2, 50P-3 Pickup	0.01 - 5.00 x In, step 0.01 x In		
	50P/51P Curves	Selectable ANSI and IEC Inverse-time (IDMT) and Definite time (DT) curves		
	50P/51P Time multiple	0.05 - 15.00, step 0.01		
	50P/51P Time delay	0.020 - 200.000 s, step 0.001 s		
	50P/51P Curve reset mode	Immediate, Inverse or definite time		
	51P, 50P-1, 50P-2 Operate mode	DFT, RMS or Peak-to-Peak		
	50P-3 Operate mode	Peak-to-Peak (fixed)		
Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	51P	±1.5% of the set value or ±0.002 x I_n		
	50P-1, 50P-2 and 50P-3	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Pickup time [1) 2)]		Minimum	Typical	Maximum
	50P-3: I_{Fault} = 2 x set Pickup value	16 ms	19 ms	23 ms
	I_{Fault} = 10 x set Pickup value	11 ms	12 ms	14 ms
	51P, 50P-1 and 50P-2: I_{Fault} = 2 x set Pickup value	22 ms	24 ms	25 ms
Instantaneous operate time [1) 3)]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 x set Start value	17 ms	21 ms	25 ms
	I_{Fault} = 10 x set Start value	12 ms	15 ms	16 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 x set Start value	25 ms	27 ms	29 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Set Operate delay time = 0.02 s, Operate curve type = ANSI definite time, Measurement mode = default (depends on element), current before fault = 0.0 x I_n, f_n = 60 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.

2) Includes the delay of the signal output contact

3) Includes the delay of the heavy-duty output contact

4) Maximum Pickup value = 2.5 x I_n, Pickup value multiples in range of 1.5 to 20

Protection functions

Three-phase non-directional long time overcurrent protection (51LT)

Basic settings	51LT Pickup	0.05 - 5.00 x In, step 0.01 x In		
	51LT Curves	Selectable ANSI and IEC long-time Inverse-time (IDMT) and Definite time (DT) curves		
	51LT Time multiple	0.05 - 15.00, step 0.01		
	51LT Time delay	0.020 - 200.000 s, step 0.001 s		
	51LT Curve reset mode	Immediate, Inverse or definite time		
	51LT Operate mode	DFT, RMS or Peak-to-Peak		
Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	51LT	±1.5% of the set value or ±0.002 x I_n		
Pickup time [1) 2)]		Minimum	Typical	Maximum
	51LT: I_{Fault} = 2 x set Pickup value	22 ms	24 ms	25 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Set Operate delay time = 0.02 s, Operate curve type = ANSI definite time, Measurement mode = default (depends on element), current before fault = 0.0 x I_n, f_n = 60 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements.
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact
4) Maximum Pickup value = 2.5 x I_n, Pickup value multiples in range of 1.5 to 20

Non-directional neutral and ground overcurrent protection (50N/51N, 50G/51G)

Basic settings	51N(G) Pickup	0.05 - 5.00 x In, step 0.01 x In		
	50N(G)-1, 50N(G)-2, 50N(G)-3 Pickup	0.01 - 5.00 x In, step 0.01 x In		
	50N(G)/51N(G) Curves	Selectable ANSI and IEC Inverse-time (IDMT) and Definite time (DT) curves		
	50N(G)/51N(G) Time multiple	0.05 - 15.00, step 0.01		
	50N(G)/51N(G) Time delay	0.020 - 200.000 s, step 0.001 s		
	50N(G)/51N(G) Curve reset mode	Immediate, Inverse or definite time		
	51N(G), 50N(G)-1, 50N(G)-2 Operate mode	DFT, RMS or Peak-to-Peak		
	50N(G)-3 Operate mode	Peak-to-Peak (fixed)		
Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	51N/51G	±1.5% of the set value or ±0.002 x I_n		
	50N-1, 50N-2, 50G-1 and 50G-2 and 50N-3 and 50G-3	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Pickup time [1) 2)]		Minimum	Typical	Maximum
	50N-3, 50G-3: I_{Fault} = 2 x set Pickup value	16 ms	19 ms	23 ms
	I_{Fault} = 10 x set Pickup value	11 ms	12 ms	14 ms
	51N, 50N-1, 50N-2, 51G, 50G-1 and 50G-2: I_{Fault} = 2 x set Pickup value	22 ms	24 ms	25 ms
Instantaneous operate time [1) 3)]		Minimum	Typical	Maximum
	50N-3, 50G-3: I_{Fault} = 2 x set Pickup value	19 ms	23 ms	27 ms
	I_{Fault} = 10 x set Pickup value	14 ms	16 ms	17 ms
	51N, 50N-1, 50N-2, 51G, 50G-1 and 50G-2: I_{Fault} = 2 x set Pickup value	24 ms	27 ms	29 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) Set Operate delay time = 0.02 s, Operate curve type = ANSI definite time, Measurement mode = default (depends on element), current before fault = 0.0 x I_n, f_n = 60 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Includes the delay of the heavy-duty output contact

4) Maximum Pickup value = 2.5 x I_n, Pickup value multiples in range of 1.5 to 20

Non-directional sensitive earth fault protection (50SEF)

Basic settings	50SEF Pickup	0.10 - 40.00 x In, step 0.01 x In		
	50SEF Time delay	0.020 - 200.000 s, step 0.001 s		
Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	50SEF	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Pickup time [1) 2)]		Minimum	Typical	Maximum
	50SEF: I_{Fault} = 2 x set Pickup value I_{Fault} = 10 x set Pickup value	 16 ms 11 ms	 19 ms 12 ms	 23 ms 14 ms
Instantaneous operate time [1) 3)]		Minimum	Typical	Maximum
	550SEF: I_{Fault} = 2 x set Pickup value I_{Fault} = 10 x set Pickup value	 19 ms 14 ms	 23 ms 16 ms	 27 ms 17 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) Set Operate delay time = 0.02 s, Operate curve type = ANSI definite time, Measurement mode = default (depends on element), current before fault = 0.0 x I_n, f_n = 60 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

2) Includes the delay of the signal output contact

3) Includes the delay of the heavy-duty output contact

4) Maximum Pickup value = 2.5 x I_n, Pickup value multiples in range of 1.5 to 20

Negative phase-sequence current protection (46-1, 46-2)

Basic Settings	46 Pickup	0.05 - 5.00 x In, step 0.01 x In		
	46 Curves	Selectable ANSI and IEC Inverse-time (IDMT) and Definite time (DT) curves		
	46 Time multiple	0.05 - 15.00, step 0.01		
	46 Time delay	0.020 - 200.000 s, step 0.001 s		
	46 Reset mode	Immediate, Inverse or definite time		
Operation accuracy		Depending on the frequency of the current measured: f_n = ±2Hz		
		±1.5% of the set value or ±0.002 x I_n		
Pickup time [1) 2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 x set Pickup value	22 ms	24 ms	25 ms
	I_{Fault} = 10 x set Pickup value	14 ms	16 ms	17 ms
Instantaneous operate time [1) 3)]		Minimum	Typical	Maximum
	I_{Fault} = 2 x set Pickup value	24 ms	26 ms	28 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4)]		
Suppression of harmonics		DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,…		

Phase discontinuity protection (46PD)

Basic Settings	46PD Pickup	10 - 100%, step 1%
	46PD Time delay	0.100 - 30.000 sec, step 0.001 sec
Operation accuracy		Depending on the frequency of the current measured: fn ±2Hz
		±2% of the set value
Pickup time		< 70 ms
Reset time		< 40 ms
Reset ratio		Typical 0.96
Retardation time		< 35 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms
Suppression of harmonics		DFT: -50dB at f = n x fn, where n = 2, 3, 4, 5,…

Three-phase thermal overload (49F)

Basic Settings	49F Current reference	0.05 - 4.00 x In, step 0.01 x In
	49F Temperature raise	0.0 - 200.0 °C, step 0.1 °C
	49F Time constant	60 - 60000 s, step 1 s
	49F Maximum temperature	20.0 - 200.0 °C, step 0.1 °C
	49F Alarm value	20.0 - 150.0 °C, step 0.1 °C
	Reclose temperature	20.0 - 150.0 °C, step 0.1 °C
Operation accuracy		Depending on the frequency of the current measured: fn ±2Hz
		Current measurement: ±0.5% or ±0.002 x I_n (at currents in the range of 0.01…4.00 x I_n)
Operate time accuracy		±2.0% or ±0.50 s

Circuit breaker failure protection (50BF)

Basic Settings	50BF failure mode	Current, Breaker status or Both
	50BF retrip mode	Disabled, Current check or Without check
	50BF retrip time	0.000 - 60.000 s, step 0.001 s
	50BF failure delay	0.000 - 60.000 s, step 0.001 s
	50BF measurement mod	DFT or Peak-to-peak
Operation accuracy		Depending on the frequency of the current measured: fn ±2Hz
		±1.5% of the set value or ±0.002 x I_n
Operate time accuracy		±1.0% of the set value or ±20 ms

Three-phase inrush current detection (INR)

Basic Settings	INR Pickup	5 - 100%, step 1%
	INR Trip delay	0.020 - 60.000 s, step 0.001 s
	62CLD-1 time	0 - 300 s, step 1 s
	62CLD-2 time	0 - 300 m, step 1 m
Operation accuracy		At the frequency f=f_n
		Current measurement: ±1.5% of set value or ±0.002 x In Ratio I2f/I1f measurement: ±5.0% of set value
Reset time		+35 ms / -0 ms
Reset ratio		Typical 0.96
Operate time accuracy		+35 ms / -0 ms

Arc flash detection (AFD)

Operation accuracy		±3% of the set value or ±0.01 x I_n		
Operate time		Minimum	Typical	Maximum
	Operation mode = "Light+current" [1) 2)]	9 ms	12 ms	15 ms
	Operation mode = "Light only" [2)]	9 ms	10 ms	12 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		

1) Phase pickup value = 1.0 x In, current before fault = 2.0 x set Phase pickup value, fn = 60Hz, fault with nominal frequency, results based on statistical distribution 200 measurements

2) Includes the delay of the heavy-duty output contact

Control functions

Autoreclosure (79)

Basic Settings	Reset time	0.100 - 1800.000 s, step 0.001 s
	Number of reclose attempts	7
	Reclose time	0.000 - 300.000 s, step 0.001 s
	Enable/Disable functions	All overcurrent functions per reclose
Operation accuracy		±1.0% of the set value or ±20 ms

17. Display

The relay's local HMI includes a large LCD screen standard. The large LCD display offers full front-panel user-interface functionality with menu navigation and menu views.

The large display offers increased front-panel usability with less menu scrolling and improved information overview than with smaller LCD screens. The large display is well-suited for all relay installations providing an easy viewing interface.

Fig. 6: Large display standard

Large display		
Character size	**Rows in the view**	**Characters per row**
Large, variable width (13x14pixels)	10	20 or more

18. Mounting methods

By means of appropriate mounting accessories the standard relay case for the 615 series relays can be flush mounted, semi-flush mounted or wall mounted. The flush mounted and wall mounted relay cases can also be mounted in a tilted position (25°) using special accessories.

Further, the relays can be mounted in any standard 19" instrument cabinet by means of 19" mounting panels available with cut-outs for one or two relays.

For the routine testing purposes, the relay cases can be equipped with Flexitest (FT) test switches, type FT-1 or FT-19R, which can be mounted side by side or below the relay cases.

Mounting methods:

- Flush mounting
- Semi-flush mounting
- Semi-flush mounting in a 25° tilt
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with Flexitest (FT) test switches to a 19"rack

Panel cut-out for flush mounting:

- Height: 6.4" ± 0.05" (161.5±1 mm)
- Width: 6.6" ± 0.05" (165.5±1 mm)

19. Relay case and relay plug-in unit

For safety reasons, the relay cases are provided with automatically operating contacts for short-circuiting the CT secondary circuits when a relay unit is withdrawn from its case. The relay case is further provided with a mechanical coding system preventing current measuring relay units from being inserted into a relay case for a voltage measuring relay unit and vice versa, i.e. the relay cases are assigned to a certain type of relay draw-out unit.

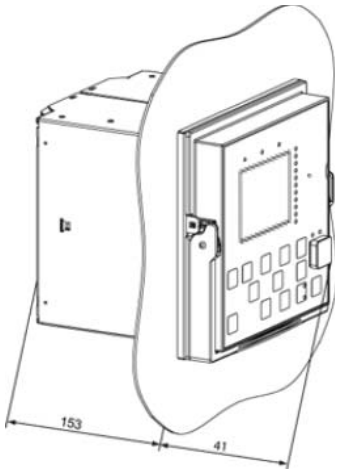

Fig. 7: Flush mounting

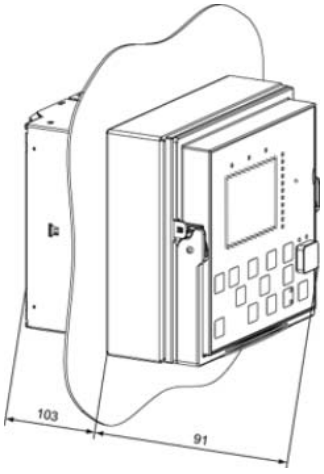

Fig. 8: Semi-flush mounting

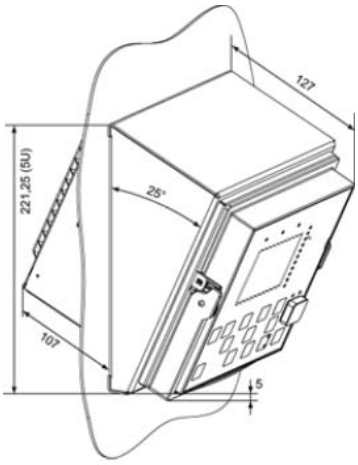

Fig. 9: Semi-flush with a 25° tilt

20. Selection and ordering data

The relay type and serial number label identifies the protection relay. The label is placed above the HMI on the upper part of the draw-out unit. An order number label is placed on the side of the draw-out unit as well as inside the case. The order number consists of a string of alphanumeric characters generated from the hardware and software modules of the relay.

Use the ordering key information in Fig. 10 to generate the order number when ordering complete protection relays.

REF615 Ordering Code		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Ex.: HAFAACADNAE1BAN1XA	**H**	**A**	**F**	**A**	**A**	**C**	**A**	**D**	**N**	**A**	**E**	**1**	**B**	**A**	**N**	**1**	**X**	**A**
Code Character	**Description**																		
1) Product Series	H: 615 (Tiger including case)																		
	J: Plug-in unit only																		
2) Standard	A: ANSI																		
3) Main Application	F: Feeder protection and control																		
4) Functional Application	A: Single breaker (CT Inputs only)				A														
5-6) Analog Inputs	3 CT					A	A												
	3 CT + Ground CT					A	B												
	3 CT + SEF CT					A	C												
7-8) Binary I/O	4 BI + 6 BO							A	A										
	11 BI + 9 BO							A	D										
9-11) Communications	One Port: Ethernet 100Base FX (LC)									N	A	E							
	One Port: Ethernet 100Base TX (RJ45)									N	B	E							
Includes Arc Flash Detection	One Port: Ethernet 100Base FX (LC)									N	F	E							
	One Port: Ethernet 100Base TX (RJ45)									N	G	E							
	None									N	N	E							
12) Language	English												1						
13) Front Panel	Large LCD (standard)													B					
14) Option 1	Reclosing														A				
	None														N				
15) Option 2	None															N			
16) Power Supply	48-250 Vdc; 48-240 Vac																1		
	24-60 Vdc																2		
17) Reserved	Reserved																	X	
18) Version	Version 1.0																		A

Example code: H A F A A C A D N A E 1 B A N 1 X A

Your ordering code:

Digit (#)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Code																		

Fig. 10: Ordering key for complete relays

21. Accessories and ordering data

Item	Order Number
Tools	
PCM600 V2.0 user tool	PCM600-20
Cables	
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0
Mounting accessories	
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19 ” rack mounting kit with cutout for one relay	TBD
19 ” rack mounting kit with cutout for two relays	TBD
Test switches:	
TBD	TBD

22. Tools

The relay is delivered as a pre-configured unit. The default parameter setting values can be changed from the front-panel user interface, the web-browser based user interface (WHMI) or the PCM600 tool in combination with the relay specific connectivity package (CP).

PCM600 offers extensive relay configuration functions such as relay signal configuration using the signal matrix tool, and IEC 61850 communication configuration including horizontal relay-to-relay communication, GOOSE.

When the web-browser based user interface is used, the relay can be accessed either locally or remotely using a web browser (IE 6.0 or later). For security reasons, the web-browser based user interface is disabled by default. The interface can be enabled with the PCM600 tool or from the front panel user interface. The functionality of the interface can be limited to read-only access by means of PCM600.

Tools

Configuration, setting and SA system tools	Version
PCM600	2.0 or later
Web-browser based user interface	IE 6.0 or later
REF615 Connectivity Package	1.0 or later
MicroSCADA Pro Substation Automation system	9.2 SP1 or later

Tool function overview

Function	WHMI	PCM600
Access control management	•	•
Signal monitoring	•	•
Relay parameter setting viewing	•	•
Alarm LED viewing	•	•
Event viewing	•	•
Relay parameter setting editing	•	•
Phasor diagram viewing	•	
Saving of parameter settings in the tool		•
Relay signal configuration (signal matrix tool)		•
IEC 61850 communication configuration, GOOSE		•
Digital fault recorder handling		•
Digital fault recorder analysis		•

• = Supported

23. Terminal diagrams

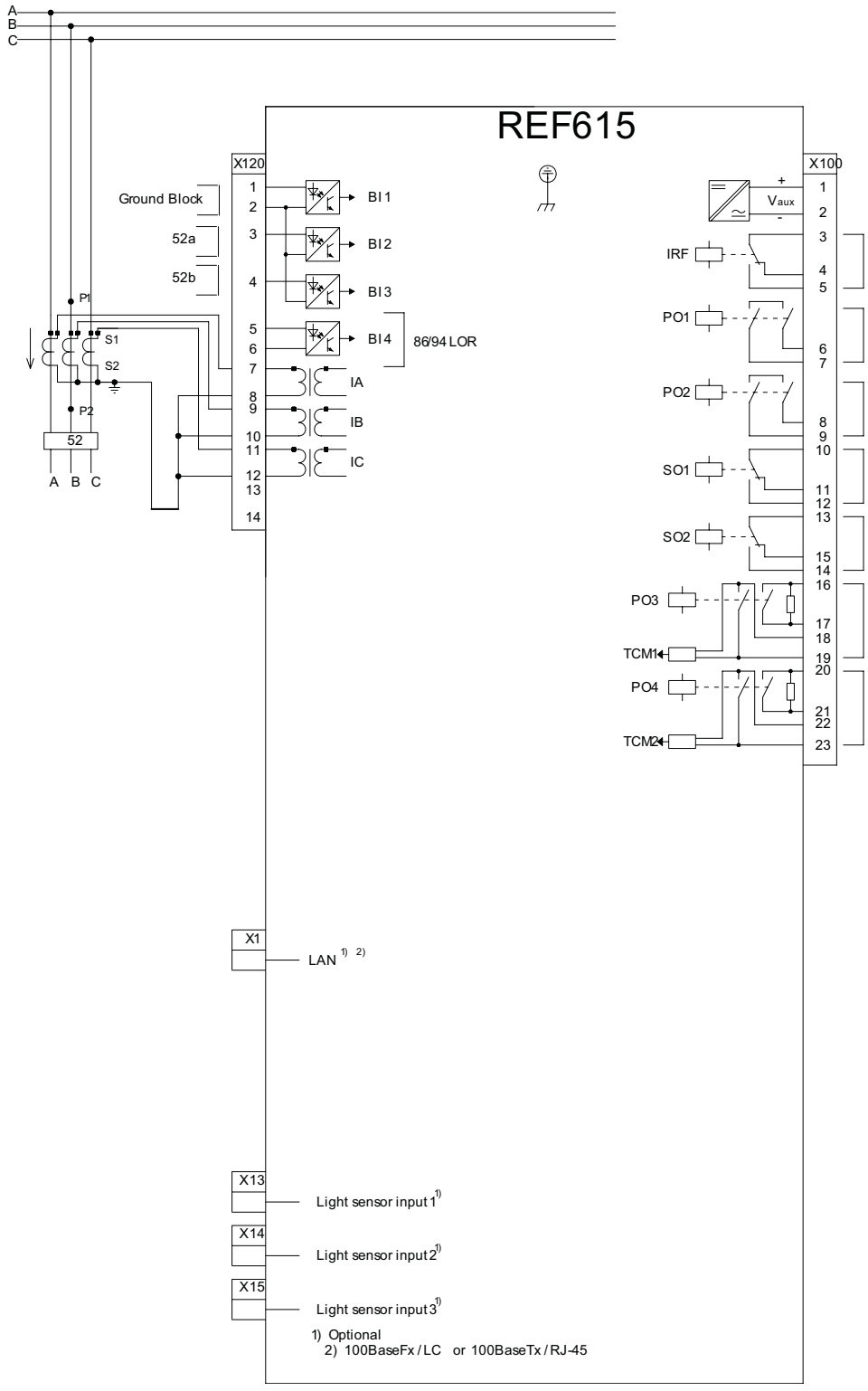

Fig. 11: Terminal diagram of "3CT" analog inputs with standard and optional Binary I/O and without optional reclosing

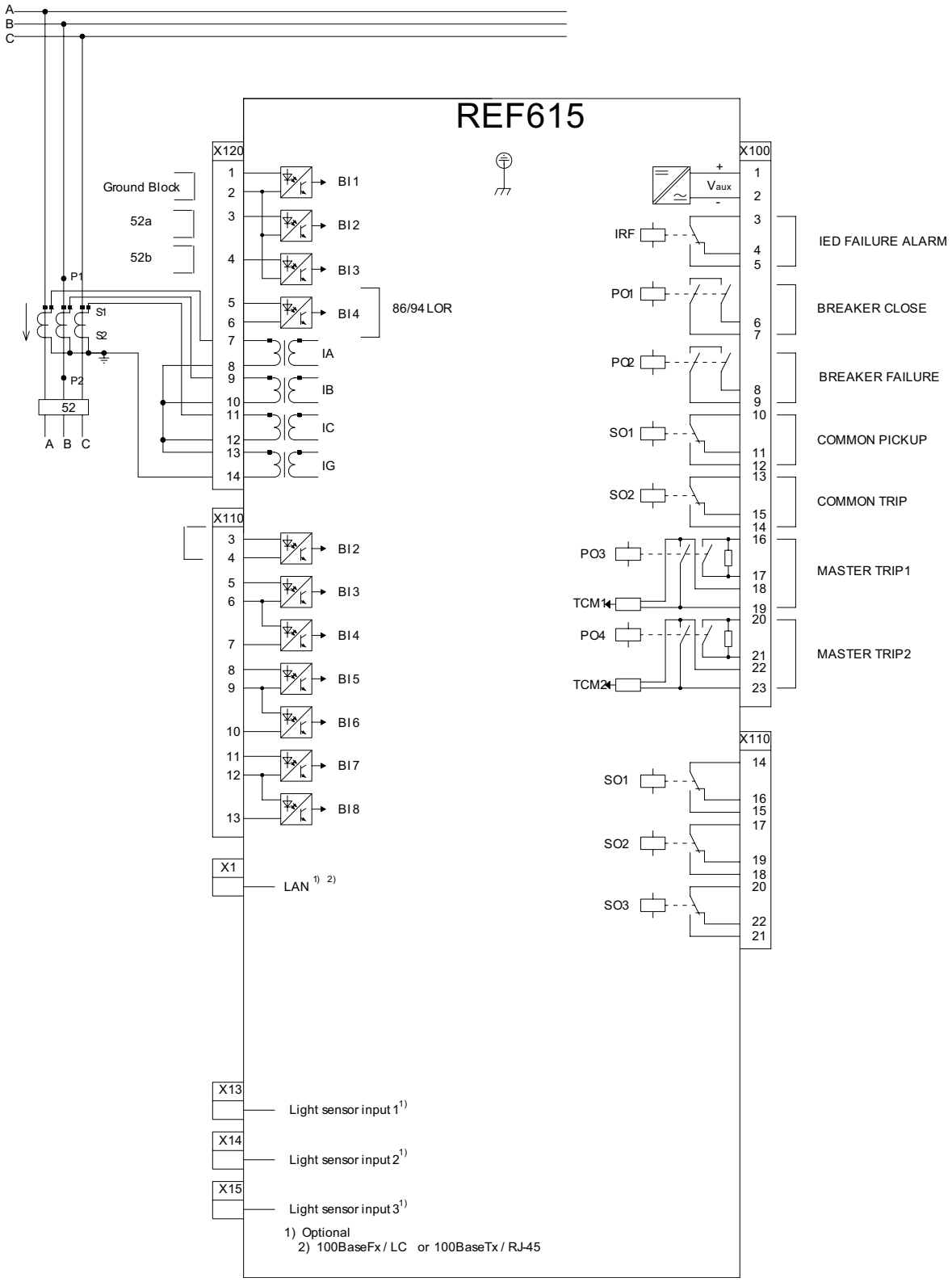

Fig. 12: Terminal diagram of "3CT + Ground CT" and "3CT + SEF CT" analog inputs with standard and optional Binary I/O and optional reclosing

24. Functions, codes and symbols

Function	IEC 61850	ANSI
Standard functions:		
Three-phase current measurement	CMMXU1	IA, IB, IC
Sequence current measurement	CSMSQI	I1, I2, I0
Three-phase transformer inrush detector	INRPHAR1	INR
Cold load timer 1 (Seconds)	TPSGAPC1	62CLD-1
Cold load timer 2 (Minutes)	TPMGAPC1	62CLD-2
Three-phase non-directional time overcurrent protection, low stage	PHLPTOC1	51P
Three-phase non-directional time overcurrent protection, high stage 1	PHHPTOC1	50P-1
Three-phase non-directional time overcurrent protection, high stage 2	PHHPTOC2	50P-2
Three-phase non-directional instantaneous overcurrent protection	PHIPTOC1	50P-3
Three-phase non-directional long time overcurrent protection	PHLTPTOC1	51LT
Neutral non-directional time overcurrent protection, low stage (Calculated 3I0)	EFLPTOC2	51N
Neutral non-directional time overcurrent protection, high stage 1 (Calculated 3I0)	EFHPTOC3	50N-1
Neutral non-directional time overcurrent protection, high stage 2 (Calculated 3I0)	EFHPTOC4	50N-2
Neutral non-directional instantaneous overcurrent protection (Calculated 3I0)	EFIPTOC2	50N-3
Negative sequence time overcurrent protection 1	NSPTOC1	46-1
Negative sequence time overcurrent protection 2	NSPTOC2	46-2
Phase discontinuity protection	PDNSPTOC1	46PD
Three-phase thermal overload protection for feeders	T1PTTR1	49F
Circuit breaker failure protection	CCBRBRF1	50BF
Trip circuit monitoring 1	TCSSCBR1	TCM-1
Trip circuit monitoring 2	TCSSCBR2	TCM-2
Electrically latched/self-resetting trip output 1	TRPPTRC1	86/94-1
Electrically latched/self-resetting trip output 2	TRPPTRC2	86/94-2
Digital fault recorder	DREC	DFR
Sequence of events recorder	SoE	SER
Fault recorder	FLTMSTA	FLR
CB control	CBXCBR1	52-1
Optional functions:		
Ground current measurement	RESCMMXU1	IG
Ground non-directional time overcurrent, low stage (Measured 3I0)	EFLPTOC1	51G
Ground non-directional time overcurrent, high stage 1 (Measured 3I0)	EFHPTOC1	50G-1
Ground non-directional time overcurrent, high stage 2 (Measured 3I0)	EFHPTOC2	50G-2
Ground non-directional instantaneous overcurrent (Measured 3I0)	EFIPTOC1	50G-3
Non-directional sensitive earth-fault protection	EFIPTOC3	50SEF
Autoreclosing	DARREC1	79
Arc flash detector 1	ARCPSARC1	AFD-1
Arc flash detector 2	ARCPSARC2	AFD-2
Arc flash detector 3	ARCPSARC3	AFD-3
High impedance fault detector	PHIZ1	HIZ

25. Notes

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